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Deputy Minister

SENIOR DIVISION ADVANCED-LEVEL CHEMISTRY

A Report Card for Ontario

PROVINCIAL REVIEWS

CHEMISTRY AND PHYSICS

Program
Implementation
and Review Branch

SENIOR DIVISION ADVANCED-LEVEL CHEMISTRY

FACULTY OF EDUCATION
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Introduction

The Senior Division advanced-level course in chemistry is usually taken by students during their third or fourth year of secondary school. Students taking the course often plan some form of postsecondary education. Many students follow this course with the Ontario Academic Course (OAC) in chemistry to prepare for university programs in the sciences. This report card provides the citizens of Ontario with a summary of the results of the recent Provincial Review of Senior Division Advanced-Level Chemistry.

What is a provincial review?

Provincial reviews form a part of the Ministry of Education's ongoing commitment to the monitoring of programs in schools. Reviews inform the public about the performance of the Ontario educational system as well as provide information to schools and school boards to assist them in program improvement. Provincial reviews are conducted by the Ministry of Education for the following purposes:

- to provide a curriculum-based process of public accountability for the province and for local school boards
- to determine the level of student achievement and program effectiveness at the provincial level as a basis for public reporting and decision making
- to identify strategies that will ensure effective implementation of ministry guidelines
- to establish baseline information on both student achievement and program effectiveness for comparison with future reviews
- to provide instruments, procedures, and baseline information for use by schools and boards in local reviews

How was the information collected?

Information was provided by students, teachers, and school boards in Ontario. A total of 11 169 students and 312 teachers from 187 schools offering instruction in English, and 1248 students and 44 teachers from 40 schools offering the course in French, participated in the provincial sample. Individual students and teachers were not identified in any of the review results.

In addition to the provincial sample, 41 school boards chose to participate in the review process by conducting board reviews. These 251 schools, 376 teachers, and 11 850 students participated in a manner identical to those in the provincial sample schools.

The correct answer for each question can be found on the last page of your report card.

1. An example of an element is
   a) carbon dioxide
   b) air
   c) brass
   d) sulfur

Anglophone	88	100	87
Francophone	89	97	91

The classification of matter into simple categories is one of the basic skills learned by a chemist. This skill permits the prediction of chemical and physical properties and the design of separation methods.

2. The group of particles having the same number of electrons in each particle is.
   a) He Li+ Be
   b) Ne Na+ Mg2+
   c) Ar Cl- S2-
   d) Ar K+ O2-

Anglophone	44	99	57
Francophone	37	98	57

The chemical properties of elements are largely determined by the arrangement of electrons around the atom. Understanding of the arrangement of elements in the periodic table of the elements allows students to predict these electron arrangements and therefore the properties of the elements.

What kinds of information were collected?

The review collected the following information:

- courses of study prepared at the school level to indicate learning objectives, teaching strategies, evaluation techniques, and resources
- details about teaching strategies used in the chemistry classrooms, including resources, methodologies, and evaluation techniques
- student-achievement data, indicating students' knowledge of chemistry, their ability to apply chemistry concepts, and their ability to perform tasks involving higher-order thinking skills
- information on student attitudes towards chemistry and the chemistry course

Although the provincial review collected information in all of these areas, this report card is limited to reporting on student achievement and student opinions on science-related issues. A more detailed report of the complete results of this review may be found in the publication *Senior Division Advanced-Level Chemistry: Educators' Report*, available in both English and French versions.

What aspects of the Senior Division advanced-level chemistry course were included in the review?

The Senior Division chemistry program is an introduction to the language of chemistry, with an emphasis on the description of the chemical and physical properties of elements and simple compounds. Students use the periodic table of the elements and simple atomic structure to explain observed properties.

Student achievement was measured in the following six content areas, which were common to the guideline issued in 1966 and the new guideline released in 1987:

- *Introduction to Chemistry:* elements and compounds, mixtures and pure substances, laws of chemical combination
- *Atomic Structure and Bonding:* the history of the development of the atomic model, theories of simple chemical bonds, the periodic table of the elements as a means of predicting chemical properties
- *Gases and Mole Problems:* the behaviour of gases and the particles that make them up. Numerical problem solving and the use of the kinetic molecular theory to predict gaseous behaviour are included.
- *Chemical Reactions – Quantitative:* the principles applied to calculate the quantities of materials involved in chemical reactions
- *Chemical Reactions – Qualitative:* the patterns of the properties of elements and compounds as they become involved in chemical reactions
- *Solutions:* the properties of solutions, calculations involving concentrations, and reactions taking place in solutions

Students were also asked their opinions about their approach to learning chemistry, science education in general, the use of computers, and the role of science in society.

How was student performance measured?

A team of chemistry educators chose 110 multiple-choice questions from the Ontario Assessment Instrument Pool (OAIP) – Chemistry. This large collection of test items has been available to chemistry teachers since 1982. In addition, 5 questions were created to which students were asked to prepare a detailed written response. All questions were related to the six content areas selected for the review.

Student assessment questions were rated as to the complexity of processing needed to answer them correctly. Three levels of questions were used in this review:

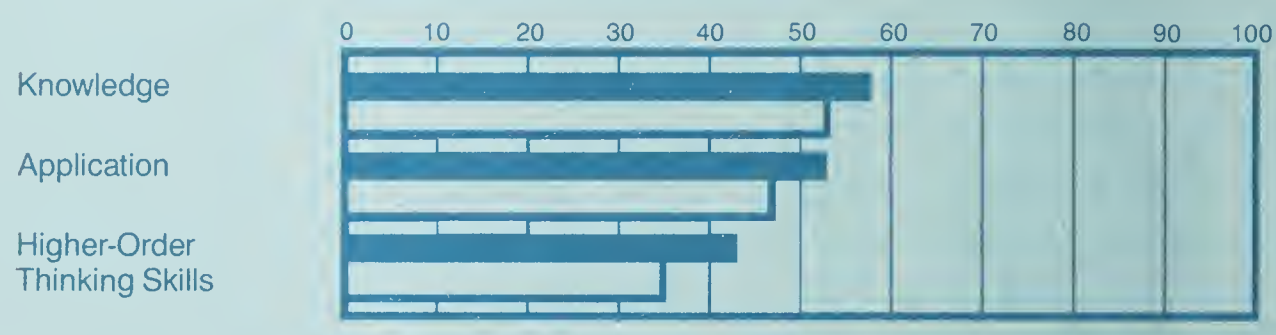
- *knowledge:* questions that could be answered by recalling factual information
- *application:* questions that required applications of factual information to new situations
- *higher-order thinking skills:* questions that required several reasoning steps or the application of concepts from a number of areas of the course

How well did students perform?

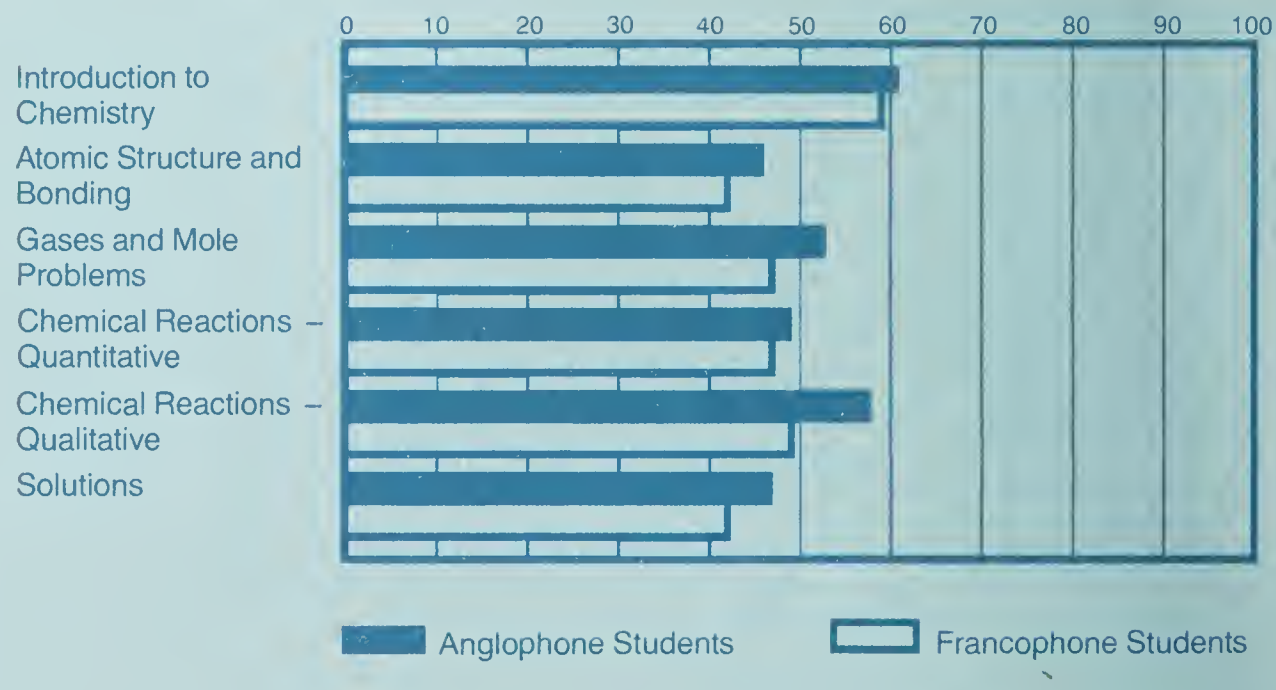
Students from Anglophone schools responded correctly to 52 per cent of all selected-response questions, while Francophone students responded correctly to 45 per cent of the questions. The results by content area and process level are shown in the accompanying graphs. Students' responses to the extended-response questions were at similar levels of achievement.

Percentage of Students Answering the Questions Correctly

by Process Level



by Content Domain



5. If alcohol is burned in air and the products of combustion are passed through limewater, a white precipitate is produced. This result provides evidence that one of the constituent elements of the alcohol is:

a) carbon.
b) chlorine.
c) hydrogen.
d) oxygen.

Anglophone	49	78	43
Francophone	29	49	34

An understanding of the characteristic properties of compounds allows chemists to identify them. Here, limewater is used to identify the gas carbon dioxide and therefore deduce one of the elements present in a sample of material.

6. In the neutralization reaction between strontium hydroxide, $Sr(OH)_2$, and perchloric acid, $HClO_4$, the products are water and

a) $Sr(ClO_4)_2$.
b) Sr_2Cl_2.
c) $Sr\ ClO_4$.
d) $SrClO_3$.

Anglophone	52	79	51
Francophone	46	71	41

Salts are products of all acid-base neutralization reactions. In this example, students are asked to apply this principle to an acid and a base that are less familiar than many they will have experienced in the classroom.

The differences between Francophone and Anglophone achievement can be attributed to many factors, including the following:

- the limited availability of French-language science resource material (e.g., texts, visual aids, films and videos)
- a scarcity of Francophone teachers with specialist qualifications in chemistry (Fifty-four per cent of the Anglophones but only 26 per cent of the Francophone chemistry teachers reported specialist qualifications in chemistry.)

Was student performance satisfactory?

The results of student performance were presented to an *interpretation panel* consisting of science educators, trustees, representatives of the business community, supervisory officers, members of faculties of education, and Ministry of Education personnel. The panel examined student responses to each question and rated them on a five-point scale: superior, strong, satisfactory, marginal, or weak. The panel's ratings of responses in the six content areas based on the 110 selected-response (multiple-choice) questions are presented in the accompanying table.

Content Domain	Francophone Students	Anglophone Students
Introduction to Chemistry	strong*	satisfactory
Atomic Structure and Bonding	marginal	marginal
Gases and Mole Problems	marginal	satisfactory
Chemical Reactions – Quantitative	satisfactory	satisfactory
Chemical Reactions – Qualitative	marginal	satisfactory
Solutions	marginal	marginal

*The results obtained by Francophone students in this content domain were affected by slight differences in the translation of some of the questions. The interpretation panel felt that this should be reflected in the rating for this domain.

When achievement was rated in terms of process level, the results for both groups were deemed satisfactory in knowledge and application but marginal in higher-order thinking skills.

In an extended-response question that asked students to speculate about the properties of a piece of material attached to the question sheets, the interpretation panel found the Anglophone results to be strong and the Francophone results satisfactory. In a question dealing with the causes, effects, and control of acid rain, the results of the Anglophone students were deemed satisfactory and the Francophone students marginal. In three other questions that asked students to design laboratory procedures to solve practical problems, responses from Anglophone students ranged from satisfactory to marginal, while those from Francophone students were rated as weak.

What do the results say about science education in Ontario?

The findings regarding Ontario students' achievement in chemistry in this review are similar to those obtained in two other recent studies – the Ontario Assessment Instrument Pool (OAIP) Field Trials in 1983 and the Second International Science Study (SSIS), as reported in the *Ontario Science Education Report Card* in 1987. While this provincial review found similar areas of concern with respect to student achievement, the information gathered on teaching practices, student opinions, and resource use will be extremely valuable in the science curriculum renewal process now under way. These results certainly reflect weaknesses in some aspects of science education in Ontario, which have been addressed in the science curriculum reform now taking place at all grade levels in Ontario schools. The Ministry of Education is working closely with teachers and their professional organizations to ensure that the results of this review will be used in a constructive manner to ensure that the science education that takes place in Ontario classrooms is of a high quality.

What was learned about the students who take chemistry?

Of the students taking chemistry, 55 per cent of the Francophones and 47 per cent of the Anglophones were female. Most students (87 per cent of the Anglophones and 86 per cent of the Francophones) expected to continue their education beyond secondary school, and many (56 per cent of the Anglophones and 43 per cent of the Francophones) expected to include science courses in these future plans.

What were students' opinions on science-related issues?

Students were asked their opinions on a variety of topics. When asked about laboratory work, more than three out of every four students said they valued hands-on laboratory work both as an enjoyable pursuit and as an aid to understanding concepts. Slightly more than half of the students perceived the value of scientific training in future careers, and a large majority did not consider a person's sex as a factor in determining ability in, or the need for, scientific pursuits. Students also indicated that they believed that science is an important factor in the development of our country and the improvement of our standard of living. A majority of students perceived chemistry as a difficult, yet an enjoyable and interesting subject.

How will the results of the review be used?

The individual schools and school boards involved in the review have been provided with their results as well as suggestions for the analysis and interpretation of these results for use in program planning and local reporting. It is expected that the information from this provincial review will be an important resource in the process of introducing and implementing the new science guidelines.

The Ministry of Education has published this report card for public information as well as a more detailed report on all aspects of the review for educators.

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